

Claims:

1 A method for making an image of an object including depth information comprising the steps of:

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- illuminating the object with a periodic pattern of light from an illuminating arrangement;

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- the illuminating arrangement being such that the pattern is in focus in a focal plane and defocuses progressively away from said focal plane;

- the object being placed such that different parts of it are at different distances from the focal plane;

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- capturing image data from the thus-illuminated object;
- analysing the captured image data to extract depth information based on the extent of defocussing of the pattern; and

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- displaying an image of the object without the pattern and with depth information.

2 A method according to claim 1, in which the image is a mask image.

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3 A method according to claim 2, in which the captured image data are captured in a single image.

4 A method according to claim 1, in which the image is an angular-composite image.

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5 A method according to claim 4, in which the image data are captured in at least two mask images differing in the angular orientation of the object about a single axis orthogonal to a line between the object and the illuminating arrangement..

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6 A method according to claim 1, in which the image is a 3D image.

7 A method according to claim 6, in which the image data are captured in at least three mask images differing in the angular orientation of the object about at least two axes orthogonal to a line joining the object and the illuminating arrangement.

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8 A method according to any one of claims 1 to 7, in which the object is placed such that it does not intersect the focal plane.

9 A method according to claim 8, in which the object is placed such that it is in a region in which rate of change of defocusing with distance from the illuminating arrangement is greatest.

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10 A method according to claim 8 or claim 9, in which the object is placed such that it is in a region in which the rate of change of defocusing with distance from the illuminating arrangement is reasonably constant.

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11 A method according to any one of claims 1 to 10, in which the pattern is removed from the image by capturing image data corresponding to out-of-phase light patterns on the object and image data from the object illuminated without the pattern.

10 12 A method according to any one of claims 1 to 11, in which the pattern is of alternating bright and dark lines.

13 A method according to claim 12, in which no region of the pattern on the object is completely unilluminated.

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14 A method according to any one of claims 1 to 13, in which the pattern is generated by a grating.

20 15 A method according to claim 14, in which the grating is of equally spaced light and dark parallel lines.

16 A method according to any one of claims 1 to 15, in which the extent of defocussing is calculated on the basis of the width of a line of the pattern.

25 17 A method according to any one of claims 1 to 16, in which the extent of defocussing is calculated on the basis of the modulation contrast of the pattern.

30 18 A method according to any one of claims 1 to 17, in which the image is scanned over parallel scan lines angled with respect to the lines of the pattern.

19 A method according to claim 18, in which the parallel scan lines are at right angles to the parallel lines of the pattern.

35 20 A method according to any one of claims 1 to 19, in which the mask image data comprise pixel image data.

21 A method according to claim 20, in which the image data are analysed on a pixel-by-pixel basis.

40 22 A method according to any one of claims 1 to 21, in which image capture is by a line scan camera.

45 23 A method according to any one of claims 1 to 21, in which image capture is by an area scan camera.

24 A method according to any one of claims 1 to 23, in which image capture is in colour.

5 25 A method according to claim 24, in which the captured image data is analysed to calculate colour from the brightest parts of the image.

26 A method according to any one of claims 1 to 25, in which calculated depth information is adjusted using a calibration.

10 27 A method according to claim 26, in which the adjustment is effected using a calibration look-up table.

15 28 A method according to any one of claims 1 to 27, in which the image is formatted for display using a preferred display system.

29 Imaging apparatus for making an image of an object including depth information, comprising:

- 20 • an illuminating arrangement adapted to illuminate the object with a periodic pattern of light;
- the illuminating arrangement being such that the pattern is in focus in a focal plane and defocuses progressively away from said focal plane;
- 25 • the object being locatable with respect to the illuminating arrangement such that different parts of it are at different distances from the focal plane;
- 30 • image data capturing means adapted to capture image data from the thus illuminated object;
- data analysis means adapted to analyse captured image data to extract depth information based on the extent of defocussing of the pattern; and
- 35 • image display means for displaying an image of the object without the pattern and with depth information'

30 Apparatus according to claim 29, in which the image data capturing means capture a mask image.

40 31 Apparatus according to claim 29 or claim 30, in which the image data capturing means comprise a one-dimensional array of detectors.

45 32 Apparatus according to claim 29 or claim 30, in which the image data capturing means comprise a two dimensional array of detectors.

- 33 Apparatus according to claim 31 or claim 32, a monochrome camera.
- 34 Apparatus according to claim 31 or claim 32, being a colour camera.
- 5 35 Apparatus according to claim 33 or claim 34, being a CCD camera.
- 36 Apparatus according to claim 33 or claim 34, being a CMOS camera.
- 10 37 Apparatus according to any one of claims 29 to 36, in which the illuminating arrangement comprises a light source, focussing means and a grating.
- 38 Apparatus according to claim 37, in which the light source comprises a source of incoherent light.
- 15 39 Apparatus according to claim 38, in which the light source comprises an incandescent filament lamp.
- 40 Apparatus according to claim 38, in which the light source comprises a quartz-halogen lamp.
- 20 41 Apparatus according to claim 38, in which the light source comprises a fluorescent lamp.
- 42 Apparatus according to claim 38, in which the light source comprises a light emitting diode.
- 25 43 Apparatus according to claim 37, in which the light source is a source of coherent light.
- 30 44 Apparatus according to claim 43, in which the light source comprises a laser.
- 45 Apparatus according to any one of claims 37 to 44, in which the focussing means comprise a lens.
- 35 46 Apparatus according to any one of claims 37 to 45, in which the focussing means comprise a mirror.
- 47 Apparatus according to claim 45 or claim 46, in which the focussing means comprise a cylindrical focussing arrangement.
- 40 48 Apparatus according to claim 45 or claim 46, in which the focussing means comprise a spherical or parabolic focussing arrangement.
- 49 Apparatus according to any one of claims 29 to 48, comprising a support for an object to be imaged.
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- 50 Apparatus according to claim 49, the support also supporting the illuminating arrangement in such relationship that the object is supported so that the focal plane does not intersect the object.
- 5 51 Apparatus according to claim 49 or claim 50, the support also supporting the illuminating arrangement in such relationship that the object is in a region in which the rate of change of defocussing with distance from the illuminating arrangement is reasonably constant.
- 10 52 Apparatus according to any one of claims 49 to 51, in which the support permits relative adjustment between the object and the illuminating arrangement.
- 53 Apparatus according to any one of claims 49 to 52, in which the support comprises a turntable.
- 15 54 Apparatus according to any one of claims 29 to 53, comprising means adapted to vary the periodic pattern of light.
- 20 55 Apparatus according to claim 54, comprising means adapted to alter the orientation of a grating producing a periodic pattern of light.
- 56 Apparatus according to any one of claims 29 to 55, in which the image display means comprise a video screen driven by software capable of simulating and manipulating a 3D image.
- 25 57 Apparatus according to any one of claims 29 to 56, substantially as hereinbefore described with reference to any one or more of the accompanying drawings.